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## METHOD FOR HEATING COMPONENTS

[0001] The present invention relates to a method for heating components prior to and/or during further processing.

[0002] Components, such as turbine blades for example, must be heated during production or maintenance and repair in order to carry out different processing operations. This heating is also referred to as pre-heating.

[0003] A process known as hardfacing is used during maintenance and repair of turbine blades, for example. Pre-heating of the turbine blades to be welded to an intended processing temperature is required in connection with hardfacing. Reliable hardfacing can only be carried out when the turbine blade to be welded is heated to the processing temperature and the intended processing temperature is maintained during the hardfacing process.

[0004] According to the related art, systems known as inductive systems are used for heating or pre-heating of components. Such inductive systems may be, for example, coils which heat the component by applying inductive energy. Heating or pre-heating of components via inductive systems has the disadvantage that, during heating or pre-heating, large temperature tolerances of up to 50°C may occur on the component to be heated. This improper temperature distribution on the component to be heated is disadvantageous. Furthermore, such inductive systems consume a large amount of energy. Another disadvantage of inductive systems is the fact that, during heating or pre-heating, higher temperatures may occur in the interior of the component than on the surface of the component. This may result in damage to the component.

[0005] On this basis, the object of the present invention is to create a novel method for heating components.

[0006] This object is achieved by a method having the features of patent Claim 1. According to the present invention, at least one laser device is used as the energy source for heating.

**[0007]** Speedier heating is achieved by using laser devices for heating the component than in heating methods known from the related art. Moreover, the use of laser devices ensures that no higher temperatures occur in the interior of the component to be heated than on its surfaces. Furthermore, laser devices have a radiant energy with a narrowly limitable specific wavelength. All this ensures that a defined amount of energy is applied to the component and advantageously affects the result of the heating of the component.

**[0008]** According to an advantageous refinement of the present invention, angles of incidence with which the laser beams hit the particular surface or each surface of the component to be heated are adjusted to the contour of the respective surface. This improves the homogeneity of the energy application, in particular to components such as turbine blades which have surfaces of different curvatures.

**[0009]** According to an advantageous embodiment of the present invention, heating of the component is measured and, as a function thereof, the heating process is controlled in such a way that the power of the individual laser device or of each laser device is adjusted for achieving an intended temperature setpoint value. This provides for adherence to the intended temperature setpoint value which is advantageous in particular when the temperature setpoint value of the heating is to be maintained over a longer period of time during processing of the component.

**[0010]** Preferred refinements of the present invention arise from the dependent subclaims and the following description. Exemplary embodiments of the present invention are explained in greater detail based on the drawing, without being restricted thereto.

**[0011]** Figure 1 shows a highly simplified representation including a component to be heated for explaining a first embodiment of the method according to the present invention;

**[0012]** Figure 2 shows a highly simplified representation including a component to be heated for explaining a second embodiment of the method according to the present invention;

[0013] Figure 3 shows a highly simplified representation including a component to be heated for explaining a third embodiment of the method according to the present invention.

[0014] The method according to the present invention for heating or pre-heating components is described in greater detail using the example of heating a turbine blade of a gas turbine with reference to Figures 1 through 3. Figures 1 through 3 each show different exemplary embodiments of the method according to the present invention.

[0015] Figure 1 shows in highly simplified form a turbine blade 10 of a high-pressure turbine of an aircraft engine. The object of the present invention is to heat turbine blade 10 of the high-pressure turbine prior to and/or during further processing. Further processing of turbine blade 10 may mean, for example, a process known as hardfacing.

[0016] According to the present invention, at least one laser device is used as the energy source for heating or pre-heating the component. Diode lasers are preferably used as laser devices. The use of diode lasers is particularly advantageous. However, other laser radiation sources may be used as energy sources alternatively or additionally to diode lasers. CO<sub>2</sub> lasers, Nd lasers, YAG lasers, or excimer lasers should be mentioned here as examples.

[0017] In the exemplary embodiment of Figure 1, turbine blade 10 to be heated is irradiated by the laser devices on two sides. This means that radiation energy is directed onto turbine blade 10 to be heated or the respective surfaces from two irradiation directions. Figure 1 shows first arrows 11 as well as second arrows 12. First arrows 11 indicate the irradiation of turbine blade 10 to be heated from a first irradiation direction and second arrows 12 indicate the irradiation of the very same from a second irradiation direction. The two irradiation directions in the sense of arrows 11 and 12 are used to irradiate two different surfaces of turbine blade 10. Turbine blade 10 is heated by the laser radiation.

[0018] According to the exemplary embodiment in Figure 2, turbine blade 10 is irradiated from four directions. Figure 2 shows first arrows 13, second arrows 14, third arrows 15, and fourth arrows 16. First arrows 13 indicate a first irradiation direction. Second arrows 14

indicate a second irradiation direction and third and fourth arrows 15, 16 indicate a third and a fourth irradiation direction. Four different surfaces of turbine blade 10 are thereby irradiated. Due to the increase in the number of irradiation directions and thus the increase in the number of the laser devices used it is possible to improve the contour-tolerant application of laser radiation energy to turbine blade 10 in such a way that homogeneous heating of turbine blade 10 may be achieved, even in the case of extremely curved surfaces of turbine blade 10.

**[0019]** It is understood that in addition to the two-sided irradiation shown in Figure 1 and the four-sided irradiation shown in Figure 2, a one-sided irradiation as well as a three-sided irradiation of turbine blade 10 are also conceivable.

**[0020]** As mentioned above, the exact selection or determination of the number of irradiation directions depends on the component to be irradiated and on the type of further processing to be carried out prior to and/or during the irradiation.

**[0021]** Figure 3 shows another exemplary embodiment of the method according to the present invention in which turbine blade 10 to be heated or pre-heated is irradiated via laser devices from four directions. First arrows 17 indicate a first irradiation direction, second arrows 18 indicate a second irradiation direction, and third and fourth arrows 19, 20 indicate a third and a fourth irradiation direction. In the exemplary embodiment of Figure 3, the angles of incidence at which the laser beams hit the surfaces of turbine blade 10 to be heated are adjusted to the contour of the respective surfaces. Figure 3 shows that the laser beams indicated by first arrows 17 hit turbine blade 10 at a different angle than the laser beams indicated by second arrows 18. By adjusting the angles of incidence of the laser devices with regard to the respective surface of turbine blade 10 to be heated, it is possible to again improve the homogeneity of the energy application to, i.e., the heating of turbine blade 10.

**[0022]** All exemplary embodiments according to Figures 1 through 3 have in common that turbine blade 10 is heated by using laser devices as energy sources. The energy is applied to turbine blade 10 to be heated contact-free via the surfaces of turbine blade 10.

**[0023]** Furthermore, it is the object of the present invention that heating or pre-heating of turbine blade 10 and thus the temperatures achieved on the respective surfaces of turbine blade 10 are measured contact-free via the surfaces. This contact-free measurement is carried out using one or multiple pyrometers. One pyrometer for temperature control is preferably used for each irradiation direction or for each surface of turbine blade 10 to be irradiated or heated. Two pyrometers for temperature measurement on the respective surfaces would be used in exemplary embodiment of Figure 1 and four pyrometers in the exemplary embodiments according to Figures 3 and 4. This yields the direct result that not only the energy application but also the temperature measurement take place contact-free via the surfaces of turbine blade 10.

**[0024]** Heating or pre-heating of the component, monitored with the aid of the contact-free temperature measurement, is used for regulating heating of turbine blade 10. Therefore, part of the object of the present invention is that one or each pyrometer measures the temperature on the respective surface of turbine blade 10 and that an appropriate measuring signal is conveyed to a regulating device (not shown). These measuring signals are processed by the regulating device in such a way that an intended temperature setpoint value is achieved on the respective surface. The power output of the laser devices is influenced by the regulating device for this purpose. After the intended temperature setpoint value is reached, the power control of the respective laser device takes over further temperature regulation.

**[0025]** As mentioned above, diode lasers are preferably used as laser devices. Particularly advantageous is the use of diode lasers which have a linear power output under linear control. It is preferred in particular that heating or pre-heating takes place in a power range of 200 Watts to 800 Watts when diode lasers are used.

**[0026]** Furthermore, diode lasers make it possible to apply radiation energy having a narrowly limited specific wavelength to turbine blade 10 to be heated. Focal distances having positive, negative, or parallel dispersion of the laser radiation energy may be used. Especially with long focal distances and parallel energy radiation, a clearly defined processing surface is achievable in the beam path, even if the position of the component to be heated or turbine blade 10 to be heated changes. The defined wavelength of the diode lasers enables particularly good

and defined limiting of the energy dispersion. This makes it possible that the surface of turbine blade 10 to be heated may be accurately irradiated and heated. Figures 1 through 3 show the parallel energy radiation from each of the irradiation directions.

**[0027]** As mentioned above, turbine blade 10 is heated in particular in connection with further processing of turbine blade 10 to be carried out prior to and/or during heating. One type of processing where heating or pre-heating of turbine blade 10 is required is the process known as hardfacing or laser beam hardfacing.

**[0028]** Laser beam hardfacing is primarily used for maintenance and repair of gas turbines, aircraft engines in particular, and produces a metallurgical bonding of base materials and additives. Laser beam hardfacing is used for maintenance and repair in connection with wear areas on turbine blades, the wear areas being primarily the leading edges of the turbine blades of high-pressure turbines. The method according to the present invention for heating or pre-heating turbine blades 10 may be used particularly advantageously in such laser beam hardfacing. The method according to the present invention is used in laser beam hardfacing for pre-heating the base material or the turbine blade to be maintained or repaired. These are heated using diode lasers as described above in connection with the method according to the present invention. By using the method according to the present invention in connection with laser hardfacing it has been found that using diode lasers, which are operated at approximately 700 W, a temperature setpoint value of approximately 950°C may be reached after an average heating period of 30 s. Laser hardfacing may be started after 40 s, the time difference of 10 s being used for homogenizing the temperature within the turbine blade to be processed. Separate laser devices are subsequently used for the actual laser hardfacing.